CAAP Quarterly Report

Date of Report: *December 29, 2016*

Contract Number: *DTPH5615HCAP09*

Prepared for: *U.S. Department of Transportation/Pipeline and Hazardous Materials Safety Administration (USDOT-PHMSA)*

Project Title: *Advancement in the Area of Intrinsically Locatable Plastic Materials*

Prepared by: *West Virginia University, Constructed Facilities Center (WVU-CFC)*

Contact Information: *Dr. Udaya B. Halabe, Professor, CEE Department, WVU*
Email: Udaya.Halabe@mail.wvu.edu
Phone: 304-293-9934

For quarterly period ending: *December 31, 2016*

Business and Activity Section

1. Generated Commitments

1.1 *Agreement Changes*

There has been no change in project participants or other contracts details during the last quarter.

1.2 *Purchases*

Some supplies have been purchased during this reporting period. The purchased supply items are listed in Table 1.

Table 1: Supplies purchased

No.	Item Description	Quantity
1	Miscellaneous items (mouse platform, laptop visor/sun-shade for field GPR testing)	1 each

2. **Graduate Students Working on the Project**

   Ph.D. Students – 1

   M.S.C.E. Student – 1

   B.S.Ch.E. Student – 1

   Note: All students have part-time appointments on research project.

3. **Status Update of Past Quarter Activities**

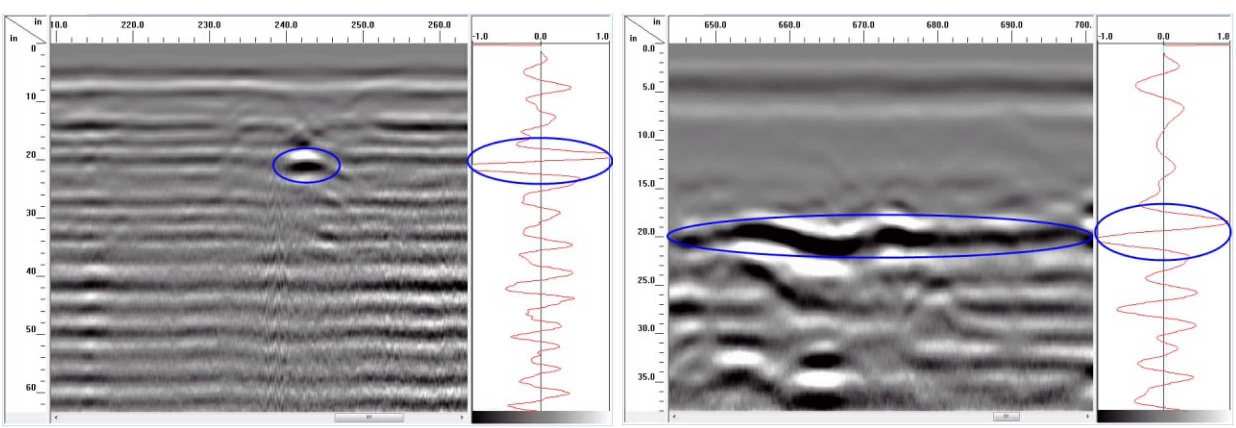
The following project planning and research activities have been completed during the last quarter (October 1 – December 31, 2016).

3.1 *Procurement of Materials*

Field data collection on sunny days was difficult because of glare from the laptop screen due to the bright sunlight. The laptop visor was used to reduce the glare during field work. Also, a mouse platform was purchased for use with the data collection Ground Penetrating Radar (GPR) unit during field work.

3.2 *GPR Testing of Buried Pipes*

GPR tesing of the burried pipe samples was continued in the past quarter. As mentioned in the previous quarterly reports, 33 pipes were buried in 3 trenches with 12ft. spacing between the trenches. Collected data was processed and enhanced to reveal signal reflection from buried pipes. Many of the 3" diameter pipers buried at 2' depth were detected in the processed GPR scans performed during the quarter. Figures 1 and 2 show sample GPR data collected from the pipes buried at 2' depth.



(a) *(b)*

Figure 1: (a) Sample cross-sectional GPR scan (left) and A-scan (right) over pipe wrapped with CFRP fabric, (b) Sample longitudinal GPR scan (left) and A-scan (right) over pipes buried at 2' depth

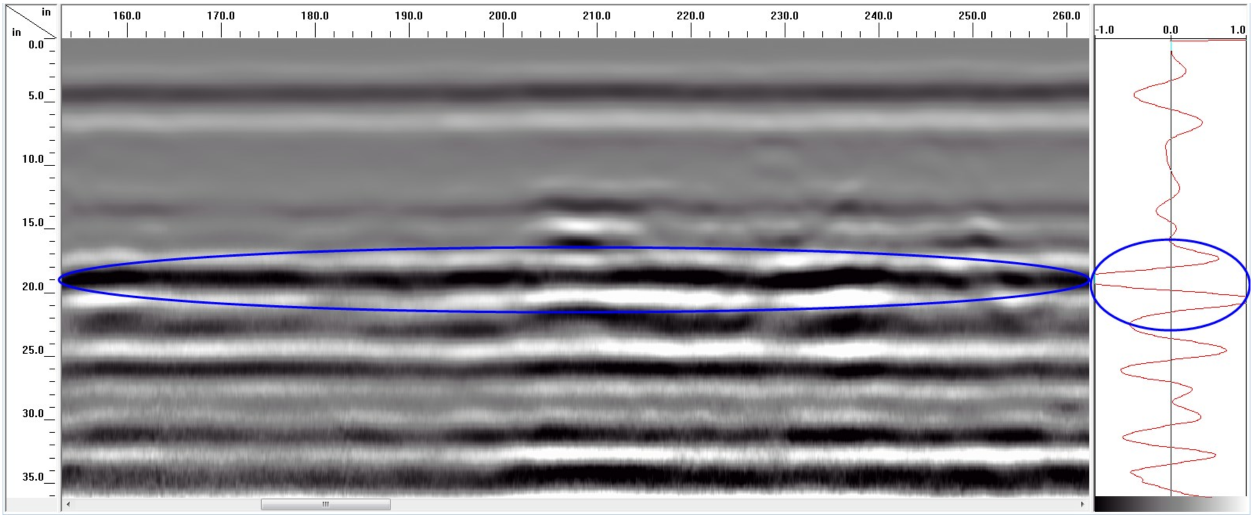


Figure 2: Longitudinal GPR scan over pipes

The hyperbolic feature in Figure 1(a) and the highlighted features in Figure 1(b) and Figure 2 in the GPR cross-sectional scan (B-scan) and the corresponding signal at these locations (A-scan), marked by blue ellipse, shows radar signal reflections from burried pipes.

The research site was relatively wet during data collection, with soil dielectric sonstant of 19.75 and 21.65 at 2' and 4' depth respectively. It is anticipated that it will be easier to detectect pipes buried at 4' depth when the soil becomes relatively dry.

3.3 *Gas Leak Detection*

Figure 3 shows a sealed wooden box containing a pipe with compressed gas buried in soil. For initial experiments, carbon dioxide was selected since it is non-toxic and non-combustible. The chosen piping material for this model was a standard 2” PVC pipe roughly 56” long to allow for overhang outside of the steel pipe. This overhang was necessary in order to allow for a seal to be placed around outside of the PVC pipe that could also fit around the edge of the steel pipe as well. A section of rubber tire tubing was used in order to create this seal on both ends of the pipe. The rubber tubing was secured around the outside of both the 8” and 2” pipes by means of hose clamps. In order to accurately measure the pressure inside of the pipe, a pressure gauge was connected to one end of the PVC pipe. The chosen pressure gauge is shown in Figure 4, and measures pressures up to 30 psig.

A hole with a diameter of 0.013 inch (a No. 80 drill bit) was drilled into the middle of the length of PVC pipe to allow for the simulation of a gas leak in the system.

Figure 3: Fully constructed housing apparatus

Figure 4: 30 psig pressure gauge

In order to detect and measure the quantity of the CO_2 leaking from inside of the PVC pipe, additional gas-sensing equipment was needed. The chosen experimental apparatus was an on-line mass spectrometer. The mass spectrometer used to conduct this analysis was the LM99 Cirrus, manufactured by MKS Instruments. The mass spectrometer could detect low quantities of CO_2 (down to the ppm range) in the air, and was used in order to measure the concentration of CO_2 inside of the housing apparatus once the CO_2 from the tank was released into the apparatus and the leak simulation tests began. Figure 5 shows the mass spectrometer as well as the computer necessary to operate it.

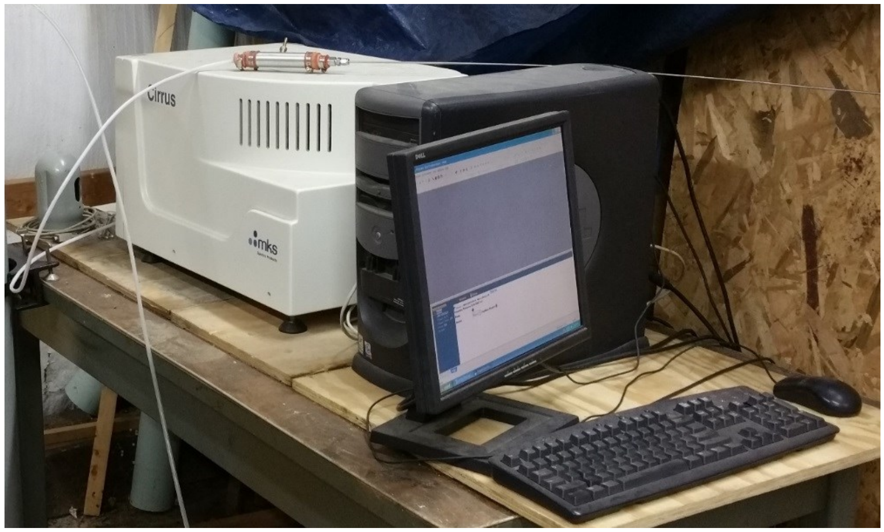


Figure 5: Mass spectrometer and associated experimental equipment

Pressure versus time trial data was obtained by pressurizing the PVC pipe to a desired level, and then isolating it from the CO_2 tank by closing the valve. Then, through the use of a stop watch, the time for the pressure to return to atmospheric pressure was recorded at intervals of 0.25 psig. A sample pressure versus time curve is shown in Figure 6. Such data can be used to calibrate a theoretical model including mass flowrate.

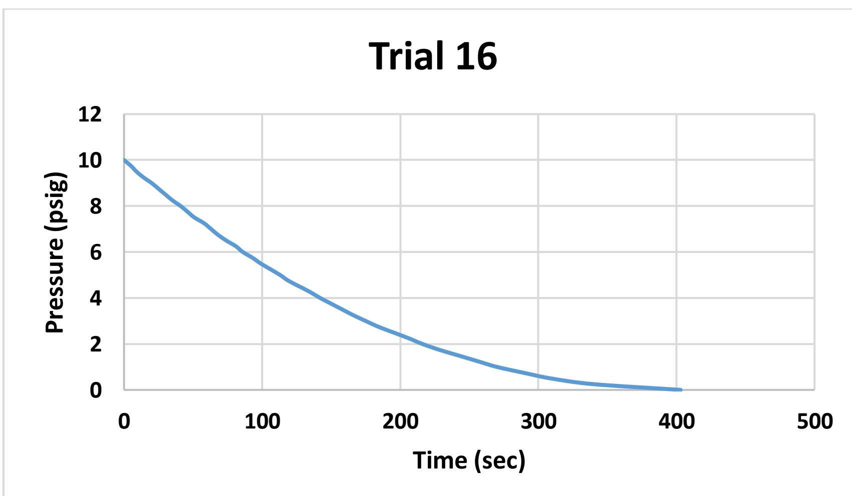


Figure 6: Pressure versus time graph for Trial 16, conducted at 10 psig

In addition to the analysis of the increase in the concentration of CO_2 gas in the apparatus, the response time of the system to increased CO_2 input was also measured. The data collected from the mass spectrometer show an immediate increase in the concentration of CO_2 gas inside the testing apparatus. In the span of less than one minute the concentration of CO_2 gas within the testing apparatus increases over tenfold from a relative concentration of less than 0.0013 to a relative concentration of over 0.013. In roughly eight minutes the concentration of CO_2 within the apparatus increases to over 100 times the atmospheric concentration to a relative concentration of over 0.13.

3.4 *Pipeline Research and Development Forum*

Four of the researchers working on current PHMSA CAAP projects at West Virginia University attended the Pipeline Research and Development Forum in Cleveland, OH. WVU attendees at the forum were:

- Dr. Udaya B. Halabe (Professor and Principal Investigator)
- Dr. Hota V. S. GangaRao (Professor and Co-Principal Investigator)
- Jonas Kavi (Ph.D. Student)
- Benjamin Imes (M.S. Student)

Jonas Kavi presented a student poster[1] on the project (Advancement in the Area of Intrinsically Locatable Plastic Materials) at the forum. All the WVU attendees at the forum participated in the working group meeting/discussions with other participants to identify current challenges faced by the pipeline industry and areas for future research.

4. Description of any Problems/Challenges

No challenges were encountered in the past quarter.

5. Planned Activities for the Next Quarter

The following activities are planned for the next quarter:

1. The detectability of the buried PVC, GFRP, and CFRP pipes will be evaluated using GPR over the next several quarters under various soil moisture conditions.
2. Various signal processing steps will be utilized using radar software to enhance the GPR data acquired from the buried pipes, so that their detectability could be improved.
3. Also, leak detection experiments for a pipe buried in a box filled with soil and carrying compressed gas will be continued.

[1] Poster available at http://primis.phmsa.dot.gov/rd/mtgs/111616/West%20Virginia%20University.pdf